COSEWIC
Assessment and Status Report

on the

Tall Beakrush
Rhynchospora macrostachya

in Canada

ENDANGERED
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Tall Beakrush — Photograph by Sean Blaney, AC CDC.

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COSEWIC
Assessment Summary

Assessment Summary – November 2014

Common name
Tall Beakrush

Scientific name
Rhynchospora macrostachya

Status
Endangered

Reason for designation
In Canada, this perennial sedge only occurs along two acidic, peaty lakeshores in southwestern Nova Scotia, where it is disjunct from its main U.S. Atlantic Coastal Plain distribution. Its small population size (ca 700 individuals total in two subpopulations) and very specific habitat needs make it vulnerable to lakeshore development, water regulation (for hydroelectric power), and shading and competition from introduced invasive plants such as Glossy Buckthorn, which benefit from increased concentrations of nutrients in these two lakes.

Occurrence
Nova Scotia

Status history
Designated Endangered in November 2014.

COSEWIC
Executive Summary

Tall Beakrush
Rhynchospora macrostachya

Wildlife Species Description and Significance

Tall Beakrush is a perennial, herbaceous sedge. Flowering stems, arising from a dense clump of basal leaves, reach 150 – 170 cm in the United States and about 100 cm in Canada. Flowers are enclosed within brown scales, with each having male and female parts and six elongate, barbed bristles. Fertilized flowers develop into a hard, flattened achene 5 to 6 mm long, topped by a greatly elongated tubercle.

Tall Beakrush is one of many species of the Atlantic Coastal Plain that are disjunct and nationally rare in southern Nova Scotia, and that have received fairly widespread attention and appreciation in the region through ongoing outreach programs. The Canadian population is isolated from others by 468 km and is the northernmost worldwide, suggesting potential significance to the species' range-wide genetic diversity. The seed-like achenes of Tall Beakrush can also be an important food for wild ducks in the southern United States.

Distribution

Tall Beakrush is predominantly a species of the Atlantic and Gulf Coastal Plains between southern Maine, northeastern Florida, and Louisiana, but it also occurs in southeast Michigan and adjacent Indiana, eastern Oklahoma and adjacent areas of Kansas, Missouri and Arkansas, and along the Tennessee-Alabama border. Isolated records are reported for Kentucky, and northern New York. Reports from Illinois, Mississippi and Vermont are erroneous. Canadian occurrence is restricted to two lakes 23 km apart in southern Nova Scotia. Canada supports less than 1% of the global population.

Habitat

Tall Beakrush is an obligate wetland plant occurring in Canada on shallow acidic open lakeshores that are fully exposed (or nearly so) during summer low water levels. Substrates are mostly gravelly, often with a thin layer of peaty organic soil on top, but some plants are on deeper peat or on shallow organic soil within cracks in exposed bedrock. In the southern United States, Tall Beakrush also occupies freshwater and slightly saline tidal marshes, swamp forests, and marshes and sloughs within tallgrass prairies, and it can occur in disturbed habitats such as ditches, all-terrain vehicle tracks, pipeline rights-of-way, rice fields and impoundments.

Biology

In Nova Scotia, Tall Beakrush flowers from July to September. Pollination is presumed to be largely or entirely by wind, as is the case with most sedges. It is believed to be self-compatible. Seed-like achenes are dispersed from the parent plant in the fall and their long bristles may facilitate dispersal via floatation or on animals. Internal and external dispersal by waterfowl over longer distances is also likely. In a closely related species, germination occurs best in drier periods than are ideal for growth. Reproduction before age one occurs in the United States but probably requires at least two or three years in Nova Scotia, based on observation of mid-sized, non-flowering rosettes. The species is non-rhizomatous but vegetative reproduction occurs over very short distances via production of new rosettes to the side of existing ones. Demographics of vegetative reproduction are unknown, as are longevity of genetic individuals and ramets, and generation time.

Population Sizes and Trends

A 2013 comprehensive count of the Canadian population found 688 individuals, 648 (95%) of which were in a 1.3 km x 0.7 km area on Carrigan Lake and 36 (5%) of which were in a 30 m stretch of shoreline on Keddy Cove on Molega Lake. Survey effort is sufficient to suggest that it is unlikely that large numbers of additional individuals would be found on these lakes, or that many additional undiscovered subpopulations are present in Canada. Trends are unknown but habitat near current subpopulations suggests stability or small population declines in the past three generations and potentially significant historical subpopulation losses from damming.

Threats and Limiting Factors

Lakeshore development has not yet affected Carrigan Lake plants but 38% of the Canadian population there is adjacent to private land potentially subject to shoreline development, and an additional 39% is on land owned by Nova Scotia Power that might one day be sold. All of the Molega Lake subpopulation (5% of the Canadian population) is in a small, undeveloped zone within shoreline otherwise occupied by cottages, and is under significant threat of further development. All plants at Carrigan Lake (95% of the Canadian population) occur within shoreline for which Nova Scotia Power has flooding rights associated with hydroelectric power generation. Nova Scotia Power believes that anthropogenic flooding has never occurred on Carrigan Lake, and suggests it is unlikely for the foreseeable future. The invasive exotic shrub Glossy Buckthorn is already present immediately around some occurrences at Carrigan Lake and occurs within 950 m of the Molega Lake subpopulation, but is believed unlikely to impact most occupied lakeshore habitat. Competitive exclusion by more aggressive plants responding to eutrophication from mink farm waste or from the cumulative effects of hundreds of additional cottages on Molega Lake is a potential future threat.

Protection, Status, and Ranks

Tall Beakrush has no legal protected status in Canada and no occurrences are within protected areas, but it has legal protection in Maine, Connecticut and Tennessee. Tall Beakrush is Critically Imperilled (N1) in Canada and in Nova Scotia (S1) and is ranked as May Be At Risk in Nova Scotia and Canada under the General Status process. It is globally secure (G4) and nationally secure in the United States (N4), but Critically Imperilled (S1) in Kentucky, Maine, Missouri and Rhode Island, borderline Critically Imperilled (S1S2) in Connecticut and Tennessee, Imperilled (S2) in Arkansas, Indiana and Kansas, Vulnerable (S3 or S3?) in New York, Virginia and North Carolina and marginally Vulnerable (S3S4) in Michigan. Tall Beakrush is Apparently Secure (S4) in Delaware, and is unranked (SNR) in Alabama, Florida, Louisiana, Maryland, Massachusetts, New Jersey, Oklahoma, South Carolina, Texas, and the District of Columbia, and Unrankable (SU) in Georgia. It may be Imperilled in Florida and marginally vulnerable in Alabama, Georgia and Massachusetts.

TECHNICAL SUMMARY

Rhynchospora macrostachya

Tall Beakrush

Rhynchospore à gros épillets

Range of occurrence in Canada: Nova Scotia

Demographic Information

Generation time (usually average age of parents in the population) Reproduction by seed and by vegetative production of new rosettes. Potential for independence of vegetatively produced rosettes (and their countability as COSEWIC individuals) unknown. See "Life Cycle and Reproduction"	Estimated 3 to 5 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? Small Molega Lake subpopulation may have declined before discovery due to cottage development in past 20 years.	Unknown
Estimated percent of continuing decline in total number of mature individuals within 2 generations. Decline or loss of Molega Lake subpopulation (5% of Canadian total) could occur due to development impacts. 39% to 78% of Canadian population at Carrigan Lake is adjacent to private land potentially subject to development, or on Nova Scotia Power land that might eventually be sold for development.	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. Large declines unlikely because Carrigan Lake subpopulation (95% of Canadian total) has seen no significant habitat changes.	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. Decline or loss of Molega Lake subpopulation (5% of Canadian total) could occur with future development impacts. Up to 78% of Canadian population at Carrigan Lake also on land potentially subject to future development.	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. As above	Unknown
Are the causes of the decline clearly reversible and understood and ceased? Declines not clearly demonstrated, but any historical declines from damming, and historical or recent declines from development have limited reversibility.	Understood, partly ceased, limited reversibility
Are there extreme fluctuations in number of mature individuals? Close relative shows rapid increases from seed bank during low water periods, but this is not known in Tall Beakrush.	None known

Extent and Occupancy Information

Estimated extent of occurrence Actual value of 11.46 km^2 reverts to the larger IAO value below.	12 km^2
Index of area of occupancy (IAO) – 2 x 2 km grid From 2 x 2 km grid aligned with 10 x 10 km UTM grid squares.	12 km^2
Is the total population severely fragmented? See "Population Spatial Structure and Variability"	No
Number of "locations"* Two landowners at Molega Lake. One location at Carrigan Lake if water level management is primary threat.	3
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence? Possible decline with cottage construction at Molega Lake.	Unknown
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? Possible decline with cottage construction at Molega Lake, but less likely than above given that a theoretical lost occurrence would need to be in a separate 4 km^2 block.	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of subpopulations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? Cottage development is ongoing at Molega Lake, reducing area, extent and quality of potential habitat near known occurrence, and is likely to affect the occurrence in future.	Yes
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See definition of location.

Number of Mature Individuals (in each subpopulation)

Population	**N Mature Individuals** (see Abundance for discussion of "individuals")
Subpop. 1 – Carrigan Lake	648
Subpop. 2 – Keddy Cove, Molega Lake	36
Total	684

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A

Threats (actual or imminent, to subpopulations or habitats)

- Shoreline Development (1.1) Removal of individuals and habitat loss from shoreline development (actual threat at both sites, likely most imminent at Molega Lake)
- Dams & Water Management (7.2) Habitat alteration from artificial water level management (non-imminent but high magnitude threat at Carrigan Lake)
- Invasive Species (8.1) Shading from invasion of exotic Glossy Buckthorn (actual and imminent threat of low magnitude at Carrigan Lake)
- Household (9.1) and Agricultural Effluents (9.3) Increased competition from other plants responding to eutrophication from mink farm waste or cottage septic systems (potential threat of high magnitude at Molega Lake, but not imminent)

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?: Globally Apparently Secure (G4) and Nationally Apparently Secure (N4) in the U.S.: Critically Imperilled (S1) in Kentucky, Maine, Missouri and Rhode Island. Critically Imperilled to Imperilled (S1S2) in Connecticut and Tennessee. Imperilled (S2) in Arkansas, Indiana and Kansas. Vulnerable (S3 or S3?) in New York, Virginia and North Carolina and Vulnerable to Apparently Secure (S3S4) in Michigan. Apparently Secure (S4) in Delaware. Unranked (SNR) and probably secure in Maryland, New Jersey, South Carolina and Texas. Unranked but possibly Imperilled in Florida. Unranked and uncommon in Alabama and Massachusetts. Unrankable (SU) and uncommon in Georgia.	
Is immigration known or possible?	Not known and unlikely
Would immigrants be adapted to survive in Canada? Southern Maine and Massachusetts populations occur in a similar climate zone	Probably
Is there sufficient habitat for immigrants in Canada? Extensive apparently suitable but unoccupied lakeshore in southern NS	Yes

Is rescue from outside populations likely? Tall Beakrush is disjunct from nearest populations in Maine (where very rare – S1) by 468 km across open ocean. Disjunct from areas where more common by 500+ km across open ocean.	No

Status History

COSEWIC: Designated Endangered in November 2014.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	B1ab(iii)+2ab(iii); C2a(ii)
Reasons for designation: In Canada, this perennial sedge only occurs along two acidic, peaty lakeshores in southwestern Nova Scotia, where it is disjunct from its main U.S. Atlantic Coastal Plain distribution. Its small population size (ca 700 individuals total in two subpopulations) and very specific habitat needs make it vulnerable to lakeshore development, water regulation (for hydroelectric power), and shading and competition from introduced invasive plants such as Glossy Buckthorn, which benefit from increased concentrations of nutrients in these two lakes.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not met: Declines below thresholds.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii) as the EO and IAO are below thresholds (12 km^2), there are 3 locations, and the habitat is declining through shoreline development and the spread of invasive non-native plants.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(ii) with < 2,500 mature individuals and > 95% occurring in one subpopulation, and the population appears to be undergoing minor declines.
Criterion D (Very Small or Restricted Total Population): Meets Threatened D1 with < 1000 (684) mature individuals; and meets Threatened D2 as the loss of the Molega Lake subpopulation through shoreline development could be a rapid event.
Criterion E (Quantitative Analysis): Not done.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2014)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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Tall Beakrush

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Figure 3. Tall Beakrush at Keddy Cove, Molega Lake with cottage beach development visible in background across the bay. Shoreline development was also present immediately southeast (right in this picture) from the shoreline area occupied by Tall Beakrush. Photograph by Sean Blaney, AC CDC 8

Figure 4. Native range (counties with light green shading in the United States, and light green dots in Canada) of Tall Beakrush (*Rhynchospora macrostachya*). The map is modified from Kartesz (2013). In the United States a whole county is shaded light green if at least one record is known. The Mississippi record may be in error (see *Global Range*)." 11

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Appendix 2. Species associated with Tall Beakrush in order of frequency, based on AC CDC (2013) records of associated species at 30 occurrences of Tall Beakrush at Carrigan and Molega Lakes. * = Atlantic Coastal Plain species. 48

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Rhynchospora macrostachya* Torr. ex A.Gray

Original Description: Annals of the Lyceum of Natural History of New York 3: 206. 1835

Synonym: *Ceratoschoenus macrostachys* Torr.
Ceratoschoenus macrostachys (Torr. ex A. Gray) A. Gray in Torr.
Rhynchospora corniculata var. *macrostachya* (Torr. ex A. Gray) Britton
Rhynchospora macrostachya Torr. ex A. Gray var. *colpophila* Fernald & Gale

English vernacular names: Tall Beakrush
Tall Beaked-rush
Tall Horned Beak Sedge

French vernacular name: Rhynchospore à gros épillets

Genus: *Rhynchospora*

Family: Cyperaceae

Order: Poales

Class: Commelinid clade (APG 2003)

Major plant group: Angiosperms, Monocots

Tall Beakrush was first described by Torrey in Gray (1835) as *Rhynchospora macrostachya*. It was subsequently called *Ceratoschoenus macrostachys* by Gray in Torrey (1836), but the species has generally been treated under *Rhynchospora* since about 1860 (IPNI 2005). The species concept for *Rhynchospora macrostachya* has varied in the past. The Narrow-fruit Beakrush (*Rhynchospora inundata*) was originally described as a variety of Tall Beakrush under the name *Ceratoschoenus macrostachys* var. *inundatus* by Oakes (1841) before being segregated at the species level by Fernald (1918). Britton (1892) treated Tall Beakrush as variety *macrostachya* of the Short-bristle Beakrush (*Rhynchospora corniculata*). Chapman treated some or all of the Broad-fruit Beakrush (*Rhynchospora careyana*) as a variety of Tall Beakrush under the names *Ceratoschoenus macrostachyus* [sic] var. *patulus* (Chapman 1860) and *Rhynchospora macrostachya* var. *patula* (Chapman 1897). All these species are today considered quite distinct from Tall Beakrush (Kral 2002) and none of them occur in Canada. Tall Beakrush is thus completely distinct from all Canadian *Rhynchospora* species. A variety specific to freshwater tidal estuarine marshes

(*Rhynchospora macrostachya* var. *colpophila*) was described from Maryland and Virginia by Fernald (1940) but has not been recognized in more recent works (Gleason and Cronquist 1991; Kral 2002; Weakley 2012).

Morphological Description

Tall Beakrush (Figures 1 to 3) is a perennial, clump-forming, herbaceous species. Culms (flowering stems) are erect and reported as 80 to 150 cm and occasionally up to 170 cm in the United States (U.S.) (Kral 2002), but flowering sometimes occurs on plants as small as about 20 cm in the Canadian population, where maximum height is about 1 m and average culm height is probably less than 60 cm (Blaney and Mazerolle pers. obs. 2009-2013). Flowering on smaller stems also occurs in the U.S., based on a culm height range of 15 to 110 cm given in Fernald (1950). The narrowly elongate and attenuate leaves occur in a dense cluster around the base of the plant and sparsely up the culm and are 3 to 12 mm (rarely 15 mm) wide. The inflorescence is composed of long-peduncled, dense clusters of elongated brown spikelets that are predominantly in terminal clusters but can also be in axillary clusters as much as 1 m below the top of the plant (Fernald 1950). The flowers are enclosed within brown scales, with each flower having male and female parts and six elongate, barbed bristles interpreted as reduced sepals and petals. Fertilized flowers develop into a single hard, flattened achene 5 to 6 mm long, which is topped by a remarkably long tubercle (the hardened remains of the style base and neck) up to 21 mm. The tubercle and spikelets of Tall Beakrush are likely the largest of all 250+ species in the genus *Rhynchospora* (Kral 2002). Tall Beakrush is reported as non-rhizomatous (Kral 2002) but in Nova Scotia can spread up to a few centimetres via production of offset rosettes of basal leaves (Blaney and Mazerolle pers. obs. 2009-2013). Tall Beakrush has a chromosome number of 2n = 18 as do the other three species in the *Rhynchospora corniculata* species complex (Moore 1997).

Figure 1. Tall Beakrush (*Rhynchospora macrostachya*) inflorescence at Carrigan Lake, Queens County, Nova Scotia. Photograph by Sean Blaney, AC CDC.

Figure 2. Tall Beakrush in lakeshore peatland on Carrigan Lake at the mouth of the brook draining Murphy Lake. Several large individuals of the invasive shrub Glossy Buckthorn (*Frangula alnus*) are visible in the background (the greyer-green mid-sized shrubs at the margin of the taller Red Maples (*Acer rubrum*)). Photograph by Sean Blaney, AC CDC.

Figure 3. Tall Beakrush at Keddy Cove, Molega Lake with cottage beach development visible in background across the bay. Shoreline development was also present immediately southeast (right in this picture) from the shoreline area occupied by Tall Beakrush. Photograph by Sean Blaney, AC CDC.

Population Spatial Structure and Variability

Canadian occurrences of Tall Beakrush are presumed to be completely genetically isolated from those in the U.S. They are 468 km disjunct from the next nearest documented U.S. occurrence at York in southernmost Maine (the only extant Maine occurrence, St. Hilaire pers. comm. 2013), and 500+ km from coastal Massachusetts, where the species is considered secure (NatureServe 2013).

Tall Beakrush is known in Canada from two lakes (Carrigan and Molega, see Defining Subpopulations) in southern Nova Scotia, with known occurrences separated by 23 km. Genetic exchange via pollen movement between the two sites may be possible, because beakrush species, with few exceptions, are believed to be predominantly or entirely wind-pollinated (Moore 1997; Costa and Machado 2012). On the decadal or century scale, genetic exchange between Carrigan and Molega Lakes via new colonization might be possible because there is considerable unoccupied but presumed suitable lakeshore habitat between the two sites, and although they are on different drainages (Carrigan Lake drains into the Mersey River via the Lake Rossignol reservoir and Molega Lake drains into the Medway River via the Wildcat River and Ponhook Lake), Carrigan Lake is separated from the Medway drainage at Apple Tree Lake by only 650 m and drainage flows from there almost directly toward the Molega Lake occurrence. Genetic exchange via wind pollination and seed dispersal is presumed possible between all plants within subpopulations. Plants occur over only 30 m at Molega Lake and over 1.3 km x 0.7 km at Carrigan Lake with maximum distance between plants of 540 m.

No work on genetic structure of American populations of Tall Beakrush has been completed, and the relatively recent discovery of Tall Beakrush in Canada (Blaney and Mazerolle 2009) means that genetic diversity of the species within Canada and in comparison with American populations has never been investigated.

Although occupied habitat at Carrigan Lake (supporting 95% of the Canadian population) is quite small, probably amounting to less than 1000 m^2 (Blaney and Mazerolle pers. obs. 2009-2013), it is believed sufficiently large to support a viable subpopulation and therefore Tall Beakrush is not considered severely fragmented in Canada (COSEWIC 2010).

Designatable Units

In Canada, Tall Beakrush is restricted to a small portion of the COSEWIC Atlantic Ecological Area in southwestern Nova Scotia, thus Canadian subpopulations should be considered a single designatable unit (DU).

Special Significance

Tall Beakrush is one of a large suite of southern species of the Atlantic Coastal Plain disjunct in southern Nova Scotia, many of which are rare in Canada (Environment Canada and Parks Canada Agency 2010). Ongoing stewardship and outreach programs have resulted in these rare species being known and appreciated by many cottagers, residents and visitors in southern Nova Scotia. Tall Beakrush is considered one of the characteristic species of Atlantic Coastal Plain Northern Pondshores from Massachusetts to Delaware Bay and it can sometimes achieve local co-dominance in such communities (*i.e.*, Coastal Plain Muck Pondshore, Westervelt *et al.* 2006).

Canadian subpopulations of Tall Beakrush are isolated from other occurrences by 468 km and are at the northeastern range limit for the species. Canadian subpopulations could thus have a disproportionate significance for the species' rangewide genetic diversity (Lesica and Allendorf 1995; Garcia-Ramos and Kirkpatrick 1997; Eckert *et al.* 2008).

The achenes of Tall Beakrush and its close relatives are an important food source for ducks in the southern U.S. (Martin and Uhler 1939), but a wide variety of Internet searches produced no other species-specific information on human use.

Tall Beakrush is sufficiently large and striking that it could be used as an ornamental species in water gardens, as is the case with White Star-Sedge (*Rhynchospora colorata*) (*e.g.*, Growing Wild Nursery 2013; Watergarden Paradise 2013). Internet sources do not suggest, however, that there is significant current horticultural use of Tall Beakrush.

No evidence of Canadian Aboriginal traditional knowledge of this species was found during the preparation of this report (Hurlburt pers. comm. 2013).

DISTRIBUTION

Global Range

Tall Beakrush is predominantly a species of the Atlantic and Gulf Coastal Plains between southern Maine and eastern Texas, but it also occurs in several disjunct areas within the eastern U.S. (Figure 4). County level distribution data from Kartesz (2011) suggests Tall Beakrush to be relatively frequent near the coast from Massachusetts to South Carolina and along the Gulf Coastal Plain in Louisiana and east Texas, but uncommon to rare from Georgia to Louisiana. Additional concentrations of occupied counties occur at the southeast end of Lake Michigan in Michigan and Indiana (an area supporting a high diversity of disjunct Atlantic Coastal Plain flora, Reznicek 1994), in eastern Oklahoma and adjacent areas of Kansas, Missouri and Arkansas, and along the Tennessee-Alabama border (Kartesz 2011). Isolated records are reported for Kentucky and northern New York (Kartesz 2011; Weldy *et al.* 2013). Reports from Mississippi and

Vermont appear to be in error[1]. There is also an Illinois report based on misidentification (Bowles *et al.* 1991). Canadian occurrence is restricted to two sites 23 km apart in Queens and Lunenburg counties, southern Nova Scotia. Canada supports less than 1% of the global population.

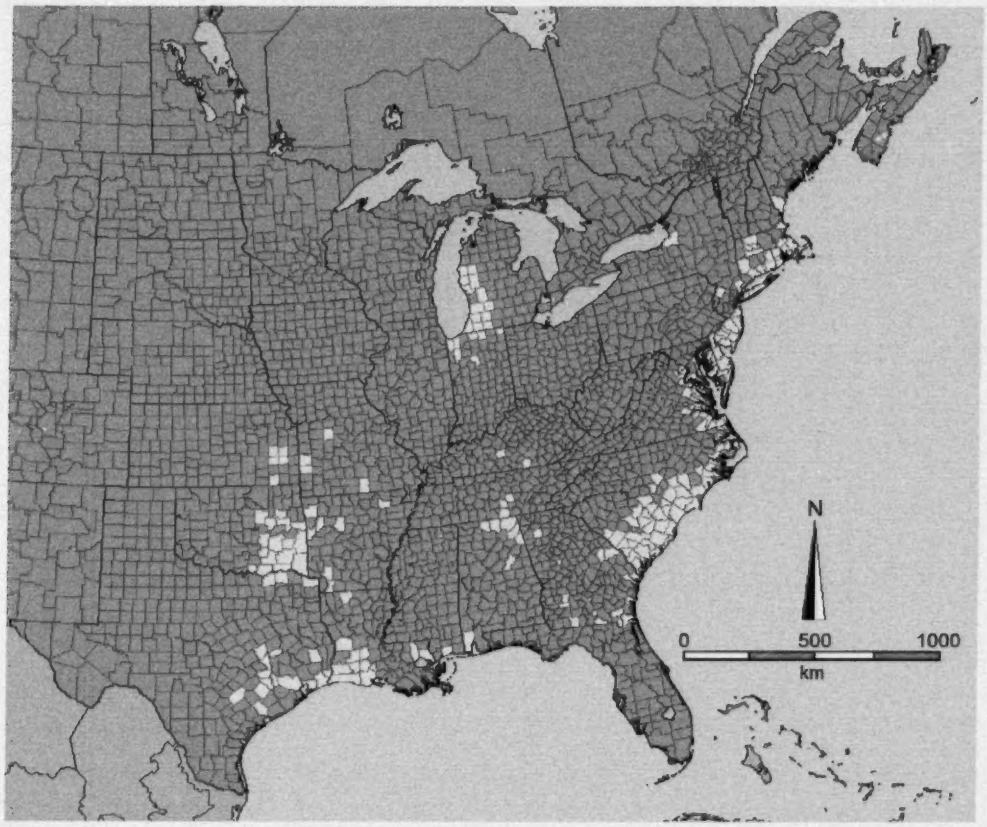

Figure 4. Native range (counties with light green shading in the United States, and light green dots in Canada) of Tall Beakrush (*Rhynchospora macrostachya*). The map is modified from Kartesz (2013). In the United States a whole county is shaded light green if at least one record is known. The Mississippi record may be in error (see *Global Range*)."

[1] Kartesz (2011) maps a single county record from Harrison County, Mississippi, and McCook (pers. comm. 2013) reports a specimen from Harrison County with identification revised from *R. macrostachya* to *R. inundata*, upon which the report was likely based. Flora of North America (Kral 2002) does not map the species from Mississippi. Popp (pers. comm. 2013) reports the single Vermont record to have been based on a misidentified specimen of a rush (*Juncus* sp.) affected by a gall.

Canadian Range

In Canada, Tall Beakrush is restricted to the COSEWIC Atlantic National Ecological Area in southwest Nova Scotia (Figure 5). It is known only from Carrigan Lake in the Mersey River watershed and 23 km east-northeast at Keddy Cove on Molega Lake in the Medway River watershed.

Despite the species' discovery in Nova Scotia (Blaney and Mazerolle 2009) after the vast majority of native species had been documented for the province (Roland and Smith 1969), the phytogeographic patterns and the context of the occurrences strongly suggest that Tall Beakrush should be considered a naturally established, native species in Nova Scotia. Tall Beakrush distribution in the U.S. and its disjunction into southern Nova Scotia from southern Maine fits a pattern shared by many other Atlantic Coastal Plain flora that are clearly native to Nova Scotia (Roland and Smith 1969; Wisheu and Keddy 1994; Clayden *et al.* 2009). Additionally, both Canadian occurrences are in habitats not significantly altered by humans and supporting a high diversity of other native and disjunct Atlantic Coastal Plain species, including the very rare and highly disjunct Redroot (*Lachnanthes caroliniana*) at Molega Lake and Poison Sumac (*Toxicodendron vernix*) in the vicinity of Carrigan Lake. The absence of earlier records of Tall Beakrush does not suggest recent introduction because specimen records (AC CDC 2013) do not indicate any botanical fieldwork prior to 2007 at Keddy Cove on Molega Lake, or prior to 2009 at Carrigan Lake.

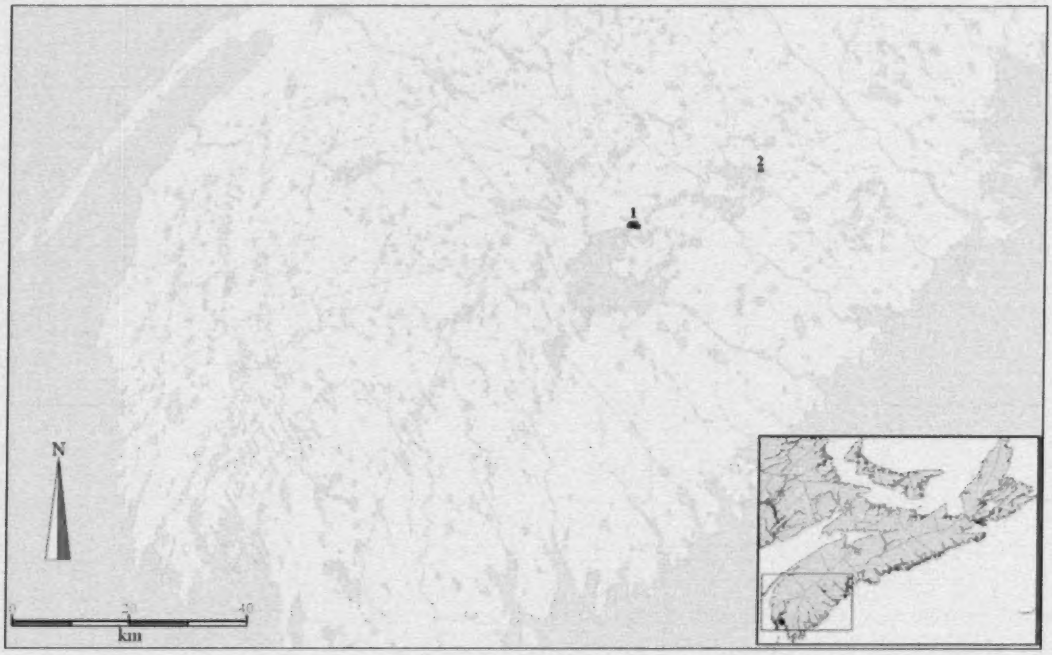

Figure 5. Distribution of Tall Beakrush (*Rhynchospora macrostachya*; red dots) in Nova Scotia at 1 – Carrigan Lake, 2 – Keddy Cove, Molega Lake. Inset map indicates location of the larger map within Nova Scotia.

Extent of Occurrence and Area of Occupancy

Actual extent of occurrence (EO) in Canada is 11.46 km^2 but under COSEWIC guidelines (COSEWIC 2010), if EO is less than index of area of occupancy (IAO), the EO is considered to be the IAO value. IAO for Tall Beakrush in Canada, derived using a 2 x 2 km grid aligned with 10 km x 10 km UTM grid squares, is 12 km^2. EO is, therefore, also 12 km^2.

Search Effort

Although Tall Beakrush was not discovered in Nova Scotia until 2009 (Blaney and Mazerolle 2009), it is clearly a native species. The absence of reports prior to 2009 does not suggest recent introduction because collection records (AC CDC 2013) give no indication that any botanists ever visited the currently occupied areas before that time. The presence of Atlantic Coastal Plain flora in southern Nova Scotia has been well known since Merritt Fernald's expeditions (Fernald 1921, 1922), and search effort for coastal plain species has been extensive. Coastal plain floristic work in southern Nova Scotia has continued from the 1950s to the present. Academic work on the ecology, distribution and local diversity of Nova Scotian coastal plain flora with a focus on conservation implications has been ongoing since the 1980s (see references in COSEWIC 2012a). The AC CDC (2013) database of vascular plant records and COSEWIC (2012a) document site visits to 322 lakes within the potential range of Tall Beakrush[2], of which 220 were visited up to 2000. Fieldwork since 2000, predominantly by Atlantic Canada Conservation Data Centre (AC CDC), Nova Scotia Department of Natural Resources and Mersey Tobeatic Research Institute (MTRI) (see references in COSEWIC 2012a) has been more intensive, with 179 lakes visited, including 102 lakes not visited prior to 2000. Most of the 102 newly visited lakes have had comprehensive coverage of their shorelines for rare plants. These figures, especially those from before 2000, are conservative estimates of the number of lakes visited by botanists because of incomplete databasing of existing specimens and lakes visited where no data were collected. They would, however, include the majority of southern Nova Scotia lakes visited by botanists.

Search effort for rare lakeshore plants has been much more intense in the vicinity of known Tall Beakrush occurrences than in most other parts of southern Nova Scotia. Excluding the Lake Rossignol reservoir, there are 60 named lakes within 10 km of the known occurrences of Tall Beakrush (Appendix 1). Of these, 36 have been comprehensively (33 lakes) or extensively (three lakes) surveyed for rare plants since 2007 (Appendix 1; AC CDC 2013). Six additional lakes have been visited by botanists since 2008 but not extensively surveyed. Lakes selected for survey in recent years were the most promising for rare plant occurrence based on: larger size and high water level fluctuation (associated with lower position in their watersheds; Hill and Keddy 1992; Hill *et al.* 1998); and on the presence of pre-existing rare plant records. As a result, the 17 largest of these lakes had already been comprehensively or extensively surveyed for rare plants prior to

[2] The southern Nova Scotia counties of Lunenburg, Queens, Shelburne, Yarmouth, Digby and Annapolis, which closely correspond to the region of highest diversity of Atlantic Coastal Plain flora in Nova Scotia. There are approximately 1,450 named lakes and ponds within this region.

fieldwork for this status report. The unsurveyed lakes within 10 km of Tall Beakrush occurrences are all small (maximum 1.14 km^2, only Black Lake and McLean Lake are over 1 km^2, and most are less than 0.3 km^2) and high in their watersheds, suggesting limited water level fluctuation (Hill and Keddy 1992; Hill *et al.* 1998) and lower potential for rare Atlantic Coastal Plain shoreline flora.

The documentation of Tall Beakrush on only two of the 322 southern Nova Scotia lakes with some botanical survey effort strongly indicates that the very limited known range is not a result of inadequate survey effort. Although Molega Lake is a well-known hotspot for rare Atlantic Coastal Plain flora, with provincially uncommon characteristics that promote coastal plain flora diversity (Hill and Keddy 1992; Hill *et al.* 1998; Blaney and Mazerolle 2009; Environment Canada and Parks Canada Agency 2010; AC CDC 2013), the habitats occupied by Tall Beakrush at Molega Lake and especially at Carrigan Lake do not appear especially unusual for southern Nova Scotia lakes (Blaney pers. obs. 1999-2012). Similar habitats should be present to some degree on a fair proportion of the roughly 1,128 lakes and ponds (out of 1,450 total, Natural Resources Canada 2003) within the potential range of Tall Beakrush for which no record of a botanist visit is available. Thus although Tall Beakrush is clearly very rare in southern Nova Scotia, there is a reasonable possibility that small numbers of additional occurrences may eventually be found.

HABITAT

Habitat Requirements

Tall Beakrush is considered an obligate wetland plant in Nova Scotia (Blaney 2011) and in all U.S. regions in which it occurs (Lichvar 2013). Kral (2002) summarizes rangewide habitat preferences as "acidic sunny wetlands, mostly pond shores, seeps, bogs, marshlands; 0–400m".

Nova Scotian habitat information is entirely based on Blaney and Mazerolle (pers. obs. 2009-2013). Tall Beakrush occurs in Nova Scotia along untreed lakeshores within a zone that experiences shallow flooding through much of the year but is fully exposed or nearly so during low water levels in mid- or late summer. In 2013, under slightly higher than seasonal average water levels, some flowering plants occurred in water up to about 25 cm deep in early September and most were in at least a few cm of water. Substrates are mostly gravelly, often with a thin layer of peaty organic soil on top, but some plants are on deeper peat or on shallow organic or peat soil within cracks in exposed bedrock. Associated species are mostly herbaceous, sometimes with low to moderate cover of the shrubs Sweet Gale (*Myrica gale*), Leatherleaf (*Chamaedaphne calyculata*) and Meadowsweet (*Spiraea alba* var. *latifolia*) (Blaney and Mazerolle pers. obs. 2009-2013). The most frequently associated species, in order of frequency, are Virginia Marsh St. John's Wort (*Triadenum virginicum* s.st.), Eaton's Witchgrass (*Dichanthelium spretum*), Three-Way Sedge (*Dulichium arundinaceum*), Bog Aster (*Oclemena nemoralis*), Sweet Gale, Twig Rush (*Cladium mariscoides*), Pickerel Weed (*Pontederia cordata*), Large Cranberry (*Vaccinium macrocarpon*), Royal Fern (*Osmunda regalis* var. *spectabilis*), and Swamp Loosestrife

(*Lysimachia terrestris*) (AC CDC 2013; see detailed analysis of associate species in Appendix 2). The lakeshore habitats occupied by Tall Beakrush in Nova Scotia support a high diversity of restricted and rare plants with affinity to the coastal plains of the eastern and southern U.S. These low biomass, high diversity lakeshore communities are maintained by acidic, nutrient-poor conditions and disturbance from fluctuating water levels, ice scour and wave action (Keddy 1985; Keddy and Wisheu 1989; Hill and Keddy 1992; Wisheu and Keddy 1994; Hill *et al.* 1998).

Occupied habitats are relatively similar in the northern part of its American range. Tall Beakrush is noted as being characteristic of Coastal Plain Muck Pondshore and Northern Peatland Sedge Pondshore community types within Atlantic Coastal Plain Northern Pondshore systems that are found near the coast between Massachusetts and northern Virginia (Westervelt *et al.* 2006). These share many characteristics and species with southwestern Nova Scotia lakeshores. In Michigan, its habitat is described as "...areas with a fluctuating water table such as coastal plain marshes, sandy lake edges, dune swales, seepages, sandy marshes, sandy and peaty edges of wetlands, and intermittent wetlands" (Michigan Natural Features Inventory 2013). Tall Beakrush also occurs in some habitats that differ from those in which it occurs in Nova Scotia. It is noted as frequent in Atlantic White-Cedar (*Chamaecyparis thyoides*) – Seaside Alder (*Alnus maritima*) Swamp in Delaware and Maryland (Westervelt *et al.* 2006). In Kansas, Tall Beakrush has been recorded in and near freshwater marshes and sloughs in unglaciated tallgrass prairies where the substrate is shale, limestone, or sandstone (Magrath and Johnson 1971; Freeman pers. comm. 2013). These occurrences and others in prairie areas of the southcentral U.S. are likely in significantly more alkaline habitats than those on the Atlantic Coastal Plain (University of Wisconsin – Madison 2002; Freeman pers. comm. 2013).

Further south, Tall Beakrush also occupies open coastal plain pondshores, as well as freshwater and slightly saline tidal marshes, swamps and interdune ponds in Virginia (Virginia Botanical Associates 2013), with the variety *colpophila* (no longer recognized; Kral 2002) having been described as restricted to fresh tidal marshes of the Chesapeake Bay and Albemarle Sound regions of Maryland and Virginia (Fernald 1918; Fernald 1950). Tall Beakrush is also noted from wet depressions and seasonal ponds within pine savannahs and flatwoods, and from Pond Cypress (*Taxodium ascendens*) swamps and hardwood swamps in South Carolina, Alabama and Louisiana (University of South Carolina 2013; Kral *et al.* 2013; Louisiana State University 2013). Herbarium records suggest that in the south it is more likely, as compared to the northern U.S., to occur in disturbed habitats such as ditches, all-terrain vehicle tracks, pipeline rights-of-way, rice fields and impoundments (Louisiana State University 2013; University of South Carolina 2013).

Habitat Trends

It is quite likely that the 1929 damming of the Mersey River, which created the Lake Rossignol reservoir, destroyed occupied Tall Beakrush habitat, because it flooded eleven named lakes with 100+ km of shoreline immediately downstream from Carrigan Lake (Belliveau and Gray 2011). Tall Beakrush habitat at Carrigan Lake has, however, likely been stable for at least the past decade, and probably longer. Despite Nova Scotia Power ownership or flowage rights along the entire shoreline, water levels on Carrigan Lake appear not to have been manipulated by Nova Scotia Power and there is currently no plan to manage them in the future (Peck pers. comm. 2013; see *Threats – Artificial Regulation of Water Levels*). There is no shoreline development on the lake at present. Camping activity is evident at the end of a vehicle track leading to the lakeshore from an abandoned farm at Carrigan Hill just north of the lake, and at least one other fire pit was found near Tall Beakrush, but neither appears to impact the species, and obvious human impacts on the lakeshore are otherwise absent (Blaney and Mazerolle pers. obs. 2009-2013).

At Keddy Cove on Molega Lake, the Tall Beakrush habitat that is currently occupied has likely been stable over the past 20+ years, but most nearby cottages appear younger than 20 years old (Blaney *et al.* pers. obs. 2013) so nearby sites could have been lost with development in that period. At Molega Lake, Tall Beakrush occurs on or near the shoreline margins of one property with a roughly 30 year old cottage (five of 35 individuals) and a larger private property with no current development (30 of 35 individuals). The roughly 30 m x 3 m area currently occupied by Tall Beakrush shows no obvious evidence of human impact. However, past impacts are visible within 20 m of these plants on the above cottage property, where the soil excavated for construction of the cottage foundation was dumped into the lake (Fielding-Croft pers. comm. 2013), creating a roughly 10 m long by up to 5 m wide berm and covering whatever plants might have been originally present.

Potential for further shoreline development impacts at Molega Lake is high as most of the Tall Beakrush occurs on a property without a cottage in an otherwise developed area, and access is good via Keddy Cove Road 100 m away. The cottage property with Tall Beakrush could change hands within the next decade, after which additional shoreline alterations associated with property improvement would be likely (Blaney *et al.* pers. obs. 2013; Fielding-Croft pers. comm. 2013). Various other shoreline impacts are present at the 15 other cottages on Keddy Cove as well as the roughly 300 cottages elsewhere on Molega Lake (Blaney and Mazerolle pers. obs. 2009-2013), but at which there are not also currently any Tall Beakrush plants. Any undiscovered occurrences on Molega Lake would also have a high potential for future impacts from shoreline development, because the shoreline is almost entirely in private ownership and new cottages are built every year (Blaney pers. obs. 2007-2013).

BIOLOGY

Life Cycle and Reproduction

Biology of Tall Beakrush in Canada is incompletely understood because of limited field observation. Fruiting is reported for the U.S. from late July to October (Fernald 1950). In Canada, flowering likely begins in July under favourable conditions, based on the earliest available observation of mature inflorescences (August 18 at Molega Lake; AC CDC 2013). The latest observation of mature inflorescences (with achenes of unknown maturity) is September 10 (AC CDC 2013) but fruiting likely occurs from August into October), based on observations on September 6, 2013 of some plants in deeper water at Carrigan Lake having inflorescences that were not yet fully elongated, releasing pollen or exposing receptive stigmas.

Several *Rhynchospora* species have independently evolved characteristics for insect pollination (Leppik 1955; Costa and Machado 2012), but Tall Beakrush lacks such characters and pollination is probably largely or exclusively by wind as with most sedges (Leppik 1955; Reznicek 1990; Friedman and Barrett 2012), including closely related beakrush species (Moore 1997, in Craine 2003). Moore (1997, in Craine 2003) noted that within each fascicle (cluster of florets), Tall Beakrush florets develop synchronously and that "the species appears to be self-compatible, unlike its close relative Narrow-fruit Beakrush". It is thus less likely to hybridize with related species.

Narrow-fruit Beakrush is reported to produce only 100 to 200 achenes per plant in Massachusetts (Craine 2003), but Tall Beakrush has larger flowering heads composed of more spikelets (Weakley 2012) and a large plant might produce several times that amount (Blaney and Mazerolle pers. obs. 2009-2013). Achenes are probably shed from the parent plant through the autumn and some likely remain on the plant until the stems, which are not especially sturdy, fall over in late fall or early winter providing a means for short-distance dispersal. Seed banking is clearly an important aspect of life history given the following: a) Tall Beakrush's use of some habitats that are only occasionally exposed above water; b) Reznicek's (pers. comm. 2013) observations of rapid response to seasonal water draw-down in Michigan; and c) the documented importance of seed banking in the closely related Narrow-fruit Beakrush (Gerritsen and Greening 1989; who found up to 1,200 viable seeds per m^2 in deep marsh habitat not dominated by Narrow-fruit Beakrush in high water periods). Gerritsen and Greening (1989) and Conti and Gunter (1984) found that Narrow-fruit Beakrush from deep marsh seed banks required oxygenated conditions for germination and found a germination response from light and heat as would occur upon exposure with lowering water levels. Narrow-fruit Beakrush germinated poorly in 3 – 4 cm of water compared to a moist but not inundated treatment, but grew best in a treatment in which it was inundated a few weeks after germination, indicating the importance of fluctuating water levels, a result that likely applies to Tall Beakrush as well. Tall Beakrush seeds might be very long-lived in soil seed banks. Gunther *et al.* (1984) found that seeds of Narrow-fruit Beakrush germinated from the oldest peat layers of any species they could identify, and their study found germination of unidentified sedge seeds that may have been Narrow-fruit Beakrush from 400+ year old peat layers (as cited in Clark 2003).

Tall Beakrush is non-rhizomatous, in contrast to closely related species that can form large, dense patches (Kral 2002). Vegetative reproduction in Tall Beakrush occurs over short distances by the production of new rosettes to the side of the parent rosette. Fernald (1950) notes that plants are "bulbous-thickened at base, with erect autumnal shoots usually crowded about the fruiting culm". The bulbous-thickened base functions as a nutrient storage organ, and the autumnal shoots and associated new rosettes overwinter and flower the next spring (Reznicek pers. comm. 2013). Narrow-fruit Beakrush grown in a greenhouse in Georgia required less than three months from germination to reach flowering. Reznicek (pers. comm. 2013) reports occasional field observations and specimens of Tall Beakrush from Michigan and Indiana indicative of fruiting within the same growing season as germination. He describes the species as a facultative annual or short-lived perennial. Growth to flowering in one year might be possible under ideal conditions in Nova Scotia, but has not yet been observed (Blaney and Mazerolle pers. obs. 2009-2013). Most individuals likely take at least two years to reach maturity, as in Michigan, where herbarium specimens having older rosette bases alongside fresh ones indicate longevity of genetic individuals of at least three years and likely longer (Reznicek pers. comm. 2013). Individual rosettes may not last into the season after flowering as the leaves and stems are soft and spongy, and likely decay rapidly (Reznicek pers. comm. 2013). Without knowing the demographics of vegetatively produced rosettes, especially the extent to which vegetatively produced rosettes could function independently of their parent rosette, generation time is hard to determine. It is roughly and conservatively estimated at three to five years based on information above and observations at Carrigan Lake of some smaller rosettes, likely more than one year old, that were infertile (Blaney *et al.* pers. obs. 2013).

Physiology and Adaptability

There is little published information on physiology of Tall Beakrush, but certain features can be inferred. With Nova Scotia at the species' extreme northern geographic range limit, cold temperatures could limit its occurrence. The range of Tall Beakrush extends across U.S. Plant Hardiness Zones 5b to 9b, corresponding to minimum temperatures of about -26°C to -4°C (USDA 2012). Its status as an obligate wetland plant throughout its range (Blaney 2011; Lichvar 2013) and its occurrence on the wetter end of the seasonally exposed lakeshore zone in areas that may not be fully exposed every year (Blaney *et al.* pers. obs. 2013) suggest that it has a high tolerance for flooding and a low tolerance for drought. As outlined in *Habitat Requirements*, occurrence in various swamp forest habitats in the southern U.S. suggest that it has some tolerance for shading, although it appears to be known primarily or exclusively from full sun habitats north of Delaware. Tall Beakrush has some tolerance for slight salinity and for tidal fluctuations based on habitats documented in Virginia (Virginia Botanical Associates 2013) and the past recognition of the freshwater tidal estuarine specialist variety *colpophila*. The occurrence of Tall Beakrush in prairie marshes in the Great Plains (i.e., Magrath and Johnson 1971; Freeman pers. comm. 2013) suggests that although it is typically a species of acidic soils (Gray 1950; Kral 2002), it can also occur in alkaline sites. As noted in *Habitat Requirements*, Tall Beakrush is able to utilize certain anthropogenic habitats in the southern part of its range, but association with disturbance appears limited in the northern part of its range.

Dispersal and Migration

Small-scale dispersal of Tall Beakrush is accomplished through the growth of new rosettes a few cm to the side of existing ones, and through the falling over of the fruiting stems at the end of the growing season. Stems can reach about 1 m in Canada and up to 1.7 m in the U.S. The achenes (seeds) of Tall Beakrush are relatively large and heavy for a sedge and do not appear well adapted for long-distance dispersal by wind or water. The six long, barbed bristles attaching at the base of the achene likely aid in dispersal. For the closely related species Narrow-fruit Beakrush, the bristles spread outward with wetting, which increases floating time (Moore 1997). Tall Beakrush may be similar. The bristles likely also contribute to animal-mediated dispersal by catching on fur or feathers (Moore 1997). Waterfowl provide a means of longer-distance dispersal. Ducks are known to eat the seeds of Tall Beakrush and closely related large beakrush species (Martin and Uhler 1939; Center for Aquatic and Invasive Plants 2002) and a certain portion may pass through the duck's gut unharmed (Mueller and van der Valk 2002 and references therein). Waterfowl can also move aquatic plant seeds within mud attached to their feet (Stiles 2000).

The traditional view on colonization of Atlantic Coastal Plain plant species into present-day Nova Scotia (Roland and Smith 1969) is that these plants reached Nova Scotia after having colonized (or having persisted throughout the period of glaciations on) land exposed by lower sea levels between present-day southern Nova Scotia and Massachusetts. This suggests a slow migration to Nova Scotia via shorter-distance dispersal events over thousands of years. A recent evaluation (Clayden *et al.* 2009) suggests this scenario may be unlikely for southern species like Tall Beakrush because offshore land is now known to have had high boreal or arctic climate, and to have been more limited in time and space than previously believed. Thus very long distance dispersal (on the scale of 450+ km between occupied areas of southern Nova Scotia and New England) may be possible for Tall Beakrush over geological time.

Interspecific Interactions

Limited observation has documented no significant insect or mammalian herbivory of Tall Beakrush within the Canadian population (Blaney and Mazerolle pers. obs. 2009-2013). In the U.S., the closely related Short-bristle Beakrush (which does not occur in Canada) is known as a larval food plant for the buprestid (metallic wood-boring) beetle *Taphrocerus gracilis* (MacRae 2004; Nelson *et al.* 2008, as cited in Webster and DeMerchant 2012), the larvae of which are leaf, root and stem miners. This beetle occurs in Nova Scotia (Webster and DeMerchant 2012) and could likely feed on Tall Beakrush given that MacRae (2004) found larval feeding by *T. gracilis* on no species other than Short-bristle Beakrush in Missouri. The fact that the beetle has been detected in Nova Scotia would suggest, however, that it is unlikely to be restricted to feeding on the very rare Tall Beakrush there. In Europe, White Beakrush (*Rhynchospora alba*), which is common in lakeshore peatlands within the Canadian range of Tall Beakrush, is known as a food plant for the Common Ringlet butterfly (*Coenonympha tullia*; seven references given in Biological Records Center 2013), which also occurs in Nova Scotia and might also feed on Tall Beakrush.

Ducks and other waterfowl feed on seeds of Tall Beakrush and closely related species in the southern U.S. (Martin and Uhler 1939; Center for Aquatic and Invasive Plants 2002) and are likely important for seed dispersal. The potential value of Tall Beakrush seeds to waterfowl is indicated by the fact that beakrush seeds (species unknown) constituted 12 to 32% of stomach contents in Fulvous Whistling Ducks (*Dendrocygna bicolor*) in Louisiana (Hohman *et al.* 1992).

Competition from high biomass and potentially dominant species like Canada Bluejoint (*Calamagrostis canadensis*), Royal Fern, Sweet Gale and other shrubs may be an important limiting factor in the distribution of Tall Beakrush in its Canadian range. Rare Atlantic Coastal Plain shoreline flora are typically stress-tolerant species with low competitive ability (Keddy 1985; Keddy and Wisheu 1989; Hill and Keddy 1992; Wisheu and Keddy 1994; Hill *et al.* 1998). Exclusion effects from neighbouring plants (by herbicide treatment) on the growth of two close relatives of Tall Beakrush (Short-bristle Beakrush and Narrow-fruit Beakrush) were examined in a brackish marsh in Louisiana by Geho *et al.* (2007). They found significant increases in biomass as a result of exclusion of neighbours. They also found that exclusion of mammalian herbivores (primarily Nutria, *Myocastor coypus*) did not significantly affect biomass.

The mycorrhizal status of Tall Beakrush is undocumented, but Dighton *et al.* 2013, documented the rare Atlantic Coastal Plain endemic Knieskern's Beakrush (*Rhynchospora knieskernii*) as facultatively mycorrhizal in fluctuating wetlands in New Jersey sand barrens, and several other species of beakrush have been documented as mycorrhizal (Lovera and Cuenca 1996; Silva *et al.* 2001) or facultatively mycorrhizal (Silva *et al.* 2001).

Fisher (1953, as cited in Clark 2003) listed Tall Beakrush and five other northeastern beakrush species as prone to smut infection of inflorescences. The fungus involved is unknown, but smut fungi in the genera *Cintractia* and *Trichocintractia* infect tropical *Rhynchospora*, inhibiting floral and inflorescence development respectively (Piepenbring 1995, *in* Clark 2003), and the Australian smut fungus *Leucocintractia scleriae* is known as Rhynchospora Smut because of its association with beakrushes (PADIL 2013). No smut infection has been observed on Canadian Tall Beakrush (Blaney and Mazerolle pers. obs. 2009-2013).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Fieldwork conducted in 2013 for this report concentrated on known Tall Beakrush sites and on the highest potential unsurveyed lakes within 10 km of known Tall Beakrush occurrences. As described below, extensive recent field surveys conducted prior to 2013 significantly shaped sampling strategy for 2013 fieldwork.

Tall Beakrush was first discovered on Carrigan Lake in 2009, during comprehensive shoreline surveys that combined walking and canoeing (Blaney and Mazerolle 2009; AC CDC 2013). Survey effort in parts of the central portion of the lake was less intense than it would have been were the surveyors focused exclusively on Tall Beakrush (Blaney and Mazerolle pers. obs. 2009-2013). The east and west ends of Carrigan Lake were considered to have been surveyed intensively enough in 2009, and/or to have been lacking in high potential habitat, such that the lack of Tall Beakrush records in those areas was thought to represent true absence. Three person-days of survey effort in 2013 were thus focused on the central portion of the lake. The extent to which additional sites were found at Carrigan Lake in 2013 was slightly surprising and suggests that some undocumented sites may also be present in the east or west ends of the lake, although undiscovered large occurrences on Carrigan Lake are still considered very unlikely (Blaney and Mazerolle pers. obs. 2009-2013).

Molega Lake is a large lake with more than 110 km of lakeshore, including islands. Extensive fieldwork since 2007 focused on mapping rare plant occurrences has covered 94 km (85%) of that shoreline (AC CDC 2013; Toms pers. comm. 2013). Molega Lake fieldwork for this report in 2013 was limited to two person days, visiting the known site and the surrounding area at the head of Keddy Cove on foot, and covering high potential peaty shoreline meadows at Cranberry Island, Softwood Island and the Black Rattle Lake channel within 3 km of the known occurrence on foot and by canoe.

As described in *Search Effort*, the highest potential lakes for rare Atlantic Coastal Plain flora within 10 km of Tall Beakrush occurrences had already been surveyed between 2007 and 2012. Fieldwork in 2013 for this status report combined on-foot surveys (especially in the highest potential habitats) with canoe-based survey to comprehensively cover the shorelines of an additional seven lakes (Payzant, Murphy, McBride, Bradley, Loon, and Cannon lakes, plus a lake-like but unnamed segment of the Wildcat River). An additional lake (McGuire Lake) was visited briefly. All but Loon Lake had seen no previous botanical survey effort. These sites were selected based on potential habitat visible on aerial photographs and occurrence within a 10 km radius of known sites. Loon Lake on the Mersey River and the Wildcat River segment were prioritized because their major water level fluctuations associated with connection to major river channels were anticipated to promote the occurrence of rare Atlantic Coastal Plain shoreline flora (Hill and Keddy 1992; Hill *et al.* 1998).

Defining Subpopulations

COSEWIC separates subpopulations if there is typically less than one successful genetic exchange per generation. Although pollen movement via wind might be possible between the Carrigan Lake and Molega Lake occurrences, the 23 km distance and relatively small subpopulation sizes at both sites probably make this unlikely and the two lakes are assumed to represent separate subpopulations. At Molega Lake all known plants are within 30 m of shoreline and are clearly a single subpopulation. At Carrigan Lake there are no gaps in occurrence larger than 540 m (AC CDC 2013), which is presumed to be within the potential dispersal distance of pollen and seeds along a lakeshore, meaning that plants at Carrigan Lake are here treated as a single subpopulation.

Abundance

Comprehensive subpopulation counts in 2013 recorded 684 mature individuals, with 648 at Carrigan Lake and 36 at Molega Lake. As a perennial that produces new rosettes to the side of existing ones, individuals can be hard to determine in cases where plants are growing in loose patches. For the above counts, individuals were defined as rosettes separated from adjacent rosettes such that leaves were not extensively overlapping and some substrate was visible between them, under the assumption that such rosettes were either independent from others or would have sufficient roots to support themselves if separated from attached rosettes by ice scour or other disturbance. The relationship between the above counts and the number of genetic individuals is unclear.

As noted under *Search Effort and Methods*, although Carrigan and Molega lakes are very well and fairly well surveyed respectively, some additional undetected individuals could be present at both subpopulations. Survey effort is sufficient to suggest that the actual total population is possibly, but not likely, over 1,000 individuals and is unlikely to be over 2,500 individuals (Blaney and Mazerolle pers. obs. 2009-2013; AC CDC 2013).

Fluctuations and Trends

Population counts have been undertaken only twice at each site since 2009 and thus provide limited evidence on population fluctuation and trends in Canada. At Molega Lake the two counts were nearly identical (32 in 2010, 35 in 2013), and the difference could easily reflect slight differences in interpretation of "individuals" or in detectability because of extent of flowering and water levels. At Carrigan Lake, the 2013 count (653 mature individuals) was considerably higher than that in 2009 (346+) and plants were found over a wider area, but the extent to which this represents actual fluctuation is unclear. The 2009 survey was a general shoreline rare plant inventory with no expectation of finding Tall Beakrush and most of the lake was covered before it was realized that Tall Beakrush was present, whereas the 2013 survey was specifically focused on finding Tall Beakrush.

As noted in *Habitat Trends*, flooding caused by construction of the Lake Rossignol dam in 1929 is quite likely to have caused significant historical population loss at the eleven flooded lakes downstream from Carrigan Lake. Limited understanding of the timing and effects of water level fluctuation at Carrigan Lake means that inferring more recent population trends there is not possible. Small, local subpopulation declines caused by cottage development on Molega Lake over the past 40 years may have occurred, but are unlikely to have been extensive. Although about 300 cottages are present on the lake, the shoreline is still intact enough and has been surveyed well enough (*i.e.* 322 GPS locations of the COSEWIC Special Concern Redroot spread extensively around the lake; AC CDC 2013) that one would expect Tall Beakrush to have been detected elsewhere if it had been at least somewhat widespread on the lake historically.

Zaremba and Lamont (1993) noted that Tall Beakrush was not among the species visible only in low water years in coastal plain ponds on Long Island, New York, meaning that extreme fluctuations are likely not typical for the species. The species' occurrence in up to 25 cm of water at the depth limits of occurrence for shoreline species (Blaney and Mazerolle pers. obs. 2009-2013) does suggest, however, that multi-year periods of especially high or low water levels could cause a population fluctuation. Observations in Nova Scotia (Blaney and Mazerolle pers. obs. 2009-2013) also suggest there could be a difference in detectability associated with water level if high water levels inhibited flowering. The rosettes of Tall Beakrush are quite similar to small rosettes of the common Wool-grass Bulrush (*Scirpus cyperinus*) and are thus easily overlooked if the striking flowering stem is not present. The possible effects of changes in detectability should be kept in mind when assessing future population changes.

Table 1. Counts of Tall Beakrush (*Rhynchospora macrostachya*) at the two Canadian subpopulations. Each subpopulation has been visited only twice, so all available counts are represented in the table. As noted in *Fluctuations and Trends*, differences between 2009 and 2013 counts at Carrigan Lake may reflect different search effort intensities.

Sub-pop.#	Name	Subpopulation (2013)	Previous Count (year)
1	Carrigan Lake	653	346+ (2009)
2	Keddy Cove, Molega Lake	35	32 (2010)
TOTAL		**688**	

Rescue Effect

Although long distance dispersal was likely significant in establishing Tall Beakrush in Nova Scotia (see *Dispersal and Migration*), rescue is likely limited for the species because the Nova Scotia population is separated from the nearest documented American occurrence in York County, Maine, by at least 468 km and from northern coastal Massachusetts, where the species is more widespread, by 490 km. Minimum distances to the nearest potential habitat in southernmost Nova Scotia (about 100 km southwest of Carrigan Lake) are about 380 km from southern Maine and 400 km from northern Massachusetts. In all cases the majority of the distance is across the open ocean of the Gulf of Maine. Rescue from subpopulations in Maine is further limited because of the species' rarity there (a single extant occurrence with 13 plants documented, St. Hilaire pers. comm. 2013). Establishment in Nova Scotia from United States populations is thus likely to be extremely rare.

THREATS AND LIMITING FACTORS

The primary threat to Carrigan Lake is the impact of long-term water level management. The primary threat to Molega Lake is shoreline development. Additional threats identified include invasive alien plant species, particularly Glossy Buckthorn, *Frangula alnus*, and the potential of changes in the lake water nutrient levels due to eutrophication by agriculture and household effluents.

Dams & Water Management (7.2)

The impacts of long-term water level management on Tall Beakrush at Carrigan Lake could be severe. Artificial regulation of water levels through dams can directly eliminate coastal plain shoreline species through flooding and can alter community composition because reduced disturbance allows competitive species to displace rarer, less competitive ones (Keddy 1989; Hill and Keddy 1992; Wisheu and Keddy 1994; Nilsson and Jansson 1995; Hill *et al.* 1998; Merritt and Cooper 2000). In addition, drainage of reservoirs in winter can expose climate-sensitive Atlantic Coastal Plain species in Nova Scotia to fatal cold temperatures (Hazel 2004; Lusk and Reekie 2007), and artificially high water levels in summer and autumn can reduce or prevent flowering and seed production (Johannson and Nilsson 2002). The elevation band occupied by Tall Beakrush at Carrigan Lake is very narrow (probably under 1 m), and 506 of 653 individuals at Carrigan Lake (78% of the subpopulation) are in areas that may be especially susceptible to water level increases (narrow shoreline zones adjacent to steep-sided drumlins that may not allow for migration toward shore, and a long, narrow point that might be almost entirely flooded with a small rise in water level).

The Carrigan Lake shoreline adjacent to areas occupied by Tall Beakrush is either owned by Nova Scotia Power or is Crown land over which Nova Scotia Power has flowage rights associated with the Lake Rossignol reservoir. Nova Scotia Power is a private corporation that generates 95% of the province's electricity and is regulated under the provincially appointed Nova Scotia Utility and Review Board (Nova Scotia Power 2013). Flowage rights are defined under the provincial *Land Registration Act* of 2001, Chapter 6, Section 1, Item 73 (1), which states that a "utility interest" (in this case the right to maintain water levels for power generation such that the land in question is flooded), "shall be enforced with priority over all other interests according to law" (Nova Scotia Office of the Legislative Counsel 2001). Nova Scotia Power does not currently regulate Carrigan Lake's water level and could not do so within the ten-year period ending in 2020 covered by their licence to operate the Lake Rossignol dam. The upper limit of Nova Scotia Power flowage rights at Carrigan Lake corresponds to the 279 foot elevation (85.04 m) contour, and the maximum operating level of the Lake Rossignol dam is 274 feet (83.51 m), with no foreseen modifications to water levels beyond that range in the future (all figures from Peck pers. comm. 2013). The elevation of Carrigan Lake shorelines occupied by Tall Beakrush is not known exactly but would be just above the Lake Rossignol maximum (Blaney and Mazerolle pers. obs. 2009-2013). Thus the only way for Nova Scotia Power to exercise its flowage rights would be to build a dam at the outlet of Carrigan Lake. There are several large lakes flowing into Lake Rossignol that are regulated by Nova Scotia Power to provide water for hydroelectric power generation, so there is precedence for similar water level management. However, the infrastructure requirements (a dam and more than 1 km of new road crossing private and Crown land) and regulatory issues associated with damming Carrigan Lake mean that if it was economically viable, it would be unlikely to occur within the next ten years. Nova Scotia Power's shoreline ownership and flowage rights on Carrigan Lake probably date from the construction of the dam that created Lake Rossignol in 1929. At that time, Nova Scotia Power was a Crown corporation and all Carrigan Lake's shoreline may have been Crown land. With little limitation on Crown to Crown transfer of land and flowage rights in that era, Nova Scotia Power acquired land and rights in areas that had only remote possibilities of ever being used (Peck pers. comm. 2013).

Historical water level regulation has likely affected Tall Beakrush subpopulations in Nova Scotia. Upon completion in 1929, the Indian Falls dam on the Mersey River flooded eleven lakes downstream from Carrigan Lake and created Lake Rossignol, Nova Scotia's largest reservoir, which extends to within 75 m of the outlet of Carrigan Lake. Suitable shoreline habitat for Tall Beakrush was undoubtedly lost to the flooding and it is quite likely that subpopulations were lost. Molega Lake has also been regulated by a small dam at its outlet that may have reduced a once-larger subpopulation. The dam was constructed in 1880 to assist river driving of logs and to regulate flow for a mill downstream at Charleston and it held 1.7 m of water. It was inconsistently maintained up until about 1965 but has not been maintained since. The remains of the dam still hold water about 25 cm above the level downstream at Hog Lake (all Molega Lake dam information from D. Freeman pers. comm. 2013).

Shoreline Development (1.1)

Shoreline development is considered a significant threat to Atlantic Coastal Plain flora communities on lakeshores (Wisheu and Keddy 1994; Eaton and Boates 2003; Environment Canada and Parks Canada Agency 2010). It is a threat at both Canadian subpopulations, but is an especially acute threat at Molega Lake. The 110 km of Molega Lake's shoreline is heavily subdivided into about 770 properties with lakeshore frontage, excluding islands. Of these, 760 are privately owned. Only about 300 properties currently have cottages (estimated from 690 buildings registered on Ponhook, Molega and adjacent lakes, COSEWIC 2009), but new cottages are built every year (Blaney pers. obs. 2007-2013) and the extensive property subdivision clearly shows the potential for hundreds of additional cottages in the future. Most of the larger undivided private land shoreline parcels are also owned by developers. The subpopulation of Tall Beakrush at Molega Lake occurs along the boundary of two private properties in Keddy Cove, extending into Crown-owned waters where plants might also be affected by the shoreline alterations of adjacent landowners (see *Habitat Protection and Ownership*). The southern property with five of 35 individuals has an existing cottage, the development of which appears to have had little impact on currently occupied habitat. As noted in *Habitat Trends*, adjacent shoreline habitat on this property 20 m away from Tall Beakrush plants was impacted by dumping of excavated soil during cottage construction about 30 years ago. Impacts on Tall Beakrush could increase at this property at any time if a decision was made to "tidy up" shoreline vegetation. This might be particularly likely if the elderly owner, who visits infrequently (Fielding-Croft pers. comm. 2013), were to sell to a new owner interested in "upgrading" the property. The adjacent property with 30 of the 35 Tall Beakrush individuals on Molega Lake currently has no cottages but is at high risk of future development given that about 15 of 28 properties on Keddy Cove already have cottages and there is good road access via Keddy Cove Road 100 m away. The undeveloped property has about 400 m of shoreline frontage and could thus house four or five cottages if subdivided. Tall Beakrush could likely co-exist with limited cottage development on this property as long as impacts were kept away from occupied habitat. Potential cumulative impacts of cottage development on Molega Lake are discussed under *Eutrophication*, below.

There are currently no cottages on Carrigan Lake but there is a high likelihood of future development. The lake is accessible from a provincial highway at the village of Caledonia by 11 km of fairly good road that is drivable to within about 170 m of Tall Beakrush plants, and an all-terrain vehicle trail extends from the end of the road to the shore about 135 m east of Tall Beakrush plants. Electrical power servicing cottages on nearby Murphy Lake extends to within about 750 m of Tall Beakrush plants, making larger-scale cottage development more likely. There is a single private property relevant to Tall Beakrush on Carrigan Lake. This property extends to the edge of a shoreline zone between 4 m and 20 m wide that is owned by Nova Scotia Power. There are 267 Tall Beakrush individuals within 15 m of the margin of this private property, representing 41% of the Carrigan Lake subpopulation and 39% of the Canadian population. These plants could be affected by cottage development on the adjacent private property because cottage owners would be likely to develop access trails to the lakeshore across the narrow zone of Nova Scotia Power ownership and otherwise alter the lakeshore as if they were the landowners.

Sandall (pers. comm. 2013) reports "...in a lot of cases where Nova Scotia Power owns flowage around reservoirs, land owners don't seem to recognize that fact and build their docks without our knowledge or permission."

If Nova Scotia Power were to determine that they have no interest in using Carrigan Lake as a reservoir they might eventually sell their shoreline land at the lake. In that case future lakeshore development impacts could also extend to the narrow point owned by Nova Scotia Power extending 230 m out into Carrigan Lake from the above private property. This land supports an additional 266 Tall Beakrush individuals (39% of the Canadian population).

Invasive Species (8.1)

The exotic shrub Glossy Buckthorn is one of the most problematic invasive plant species in Canada and the northeast U.S. (Catling and Porebski 1994; Frappier *et al.* 2003a; Catling and Mitrow 2012; IPANE 2012). Glossy Buckthorn is scattered in an old field at an abandoned farm 150 m from the majority of Tall Beakrush plants in Canada (Blaney *et al.* pers. obs. 2013). It is also well established and rapidly spreading in the open Red Maple (*Acer rubrum*) and alder (*Alnus incana* ssp. *rugosa* and *Alnus serrulata*) swamp along the brook flowing from Murphy Lake into Carrigan Lake (Blaney *et al.* pers. obs. 2013), extending to within about 5 m of 12 Tall Beakrush plants on a peat mat at the brook mouth (Figure 2). It is these individuals on deeper peat that are believed most threatened by Glossy Buckthorn. Peaty wetlands have a well-documented susceptibility to Glossy Buckthorn invasion in Wisconsin (Reinartz and Kline 1998, where it was noted as having "over-run the 1,000 ha Cedarburg Bog in 20 years"), Illinois (Taft and Solecki 1990), Michigan (Fiedler and Landis 2013), Ontario (Catling and Mitrow 2012), and Nova Scotia (Hill and Blaney 2009). As noted under Habitat Requirements, in the northern part of its range Tall Beakrush is restricted to open habitats and the development of a canopy of Glossy Buckthorn would likely have a significant negative impact on Tall Beakrush individuals.

Several other Tall Beakrush occurrences on rocky and gravelly lakeshore at Carrigan Lake occur within a few metres of Glossy Buckthorn individuals (Blaney *et al.* pers. obs. 2013). However, based on observations elsewhere in southern Nova Scotia (Blaney pers. obs. 1999-2013), Glossy Buckthorn does not appear capable of establishing dense populations on open, gravelly, seasonally flooded lakeshore, likely because of ice impacts in winter. At Molega Lake, no Glossy Buckthorn were observed in the vicinity of Tall Beakrush. Although buckthorn is sparsely established around Molega Lake, is known within 950 m of the Tall Beakrush subpopulation, and is likely spreading rapidly from larger populations nearby (Blaney pers. obs. 2007-2013), the threat to Tall Beakrush from Glossy Buckthorn is believed to be similarly low because of unsuitable shoreline habitat. Glossy Buckthorn is thus considered only a medium impact threat to Tall Beakrush in Canada at present.

Agricultural Effluents (Eutrophication) (9.3)

In recent years, eutrophication has changed from a theoretical threat to Atlantic Coastal Plain flora to one of the most significant actual threats in Nova Scotia (COSEWIC 2012a; 2012b; 2013). This is based primarily on documentation of its effects elsewhere (Ehrenfeld 1983; Moore *et al.* 1989; Zaremba and Lamont 1993; Environment Canada and Parks Canada Agency 2010), and on increased recent mink farm development. Tall Beakrush was among the suite of species considered at risk from eutrophication in coastal plain ponds in Long Island, New York, where significant losses of rare species on some ponds are presumed to have been a result of eutrophication effects (Zaremba and Lamont 1993).

Mink farming is the most significant source of inland nutrient pollution within the Atlantic Coastal Plain flora region of Nova Scotia (Brylinsky 2011, 2012), and has had significant effects on plant communities and on the status of rare Atlantic Coastal Plain flora in southern Nova Scotia (COSEWIC 2012a, b, 2013). It is an especially large source of phosphorus pollution because mink feed is treated with superphosphate to increase shelf life and reduce the occurrence of kidney stones in mink (Brylinsky 2011). Mink farm waste, including manure, carcasses and surplus food, tends to leak from inadequate storage facilities at some farms, entering local watercourses and changing them from nutrient-poor (oligotrophic) to nutrient rich (eutrophic) systems (Brylinsky 2011, 2012). Once phosphorus has entered a lake, the recovery from eutrophic conditions following a reduction in the external phosphorus loading may be slow as the phosphorus is stored in the lake sediments (Marsden 1989; White *et al.* 2002). Mink farming has undergone rapid expansion in Nova Scotia over the past decade and is the province's largest agricultural export with 1.4 million pelts produced annually by 152 farms (Flemming pers. comm. 2011). There are currently no mink farms within the watersheds flowing into Carrigan and Molega lakes, and new regulations on fur farm waste treatment (Government of Nova Scotia 2013) should require any new farms pose a reduced threat to natural systems. Eutrophication from mink farming does, however, warrant mention as a potential future threat because ongoing expansion of the industry means that any road-accessible areas with limited human population could see mink farm development, and there are many such areas upstream from Molega Lake. The total area with mink farm development potential upstream from Carrigan Lake is more limited because the lake is higher in its watershed.

Household Sewage & Urban Waste Water (9.1)

Eutrophication from the cumulative effects of hundreds of additional cottage septic systems on Molega Lake is also a possible future threat. As noted in Threats – Shoreline Development, there are roughly 300 cottages on Molega Lake, about 500 subdivided but undeveloped cottage lots and potential for several hundred additional lots on larger undeveloped private land shoreline. To this point, the shoreline flora of the lake remains dominated by species of acidic, nutrient poor conditions and shows no obvious evidence of eutrophication effects (Blaney pers. obs. 2007-2013). One would expect, however, that there could be some tipping point in the future at which nutrient inputs from septic systems begin to change shoreline plant communities in favour of more common and competitive

species. The Region of Queens Municipality municipal planning strategy recognizes that lakes have a "limited carrying capacity to support new development" (Region of Queens Municipality 2009) and has regulations and recommendations related to shoreline alteration, but unlike neighbouring Municipality of the County of Kings (2013) does not attempt to protect water quality by identifying an upper limit on the number of cottages that can be built around lakes.

Number of Locations

COSEWIC "locations" are defined at the scale of the most significant threat to each population (COSEWIC 2010). The threats differ between the two Canadian subpopulations of Tall Beakrush, meaning that each represents at least one location. Number of locations in Canada is between two and five, depending on interpretation of threats as outlined below.

At Carrigan Lake, with 95% of the Canadian population, Nova Scotia Power has flowage rights to the entire shore, and this could also make water level management for hydroelectricity production the most significant threat. This threat has very high magnitude (potential to eliminate 95% of the Canadian population), despite what is believed to be low likelihood and immediacy (see *Threats – Artificial Regulation of Water Levels*). Tall Beakrush plants at Carrigan Lake are within a very narrow elevation range along the lakeshore and would be affected relatively uniformly by water level changes, making the subpopulation a single location.

Shoreline development has the potential to impact a reasonable proportion of the Canadian population and is relatively likely to occur to some degree within ten years (see *Threats – Shoreline Development*). This would make two or three locations at Carrigan Lake.

The occurrence at Molega Lake is within a portion of the lake having extensive shoreline cottage development, and expansion of cottage-related impacts is the most significant and imminent threat there (see *Threats – Shoreline Development*). Tall Beakrush at Molega Lake is on Crown land lake margin a few metres beyond the lakeshore margin of two private properties with separate owners. The Molega Lake subpopulation is probably best considered two locations because of the differing ownership and development states of the properties (one currently undeveloped, one with an existing cottage). An argument could be made to consider it a single location because its very limited extent (about 30 m x 3 m) means that most or all individuals could be affected by a single landowner management action (such as clearing shoreline vegetation for a boat launch or swimming beach) that extended across the property boundary. All individuals are within 16 m of the boundary, which is not well marked.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Tall Beakrush does not currently have any legal protected status in Canada. It receives protection in Maine through the state's *Natural Resource Protection Act* and under Maine's Site Law, which governs approval for development (Cameron pers. comm. 2013). Tall Beakrush is also protected as a Threatened species in Connecticut under the Connecticut *Endangered Species Act* (Connecticut DEEP 2013), and is listed as Special Concern in Tennessee under the state's *Rare Plant Protection and Conservation Act* of 1985 (Crabtree 2012). No other states have legal protection for Tall Beakrush.

Non-Legal Status and Ranks

Tall Beakrush is Critically Imperilled (N1, last assessed in 2012) in Canada and in Nova Scotia (S1) (NatureServe 2013) and is ranked as May Be At Risk in Nova Scotia and Canada under the General Status process (Canadian Endangered Species Conservation Council 2011). NatureServe ranks (from NatureServe [2013], unless otherwise noted) suggest Tall Beakrush is globally secure (G4; last assessed in 1985) and nationally secure in the U.S. (N4), but is Critically Imperilled (S1) in Kentucky, Maine, Missouri (Missouri Natural Heritage Program 2014) and Rhode Island, Critically Imperilled to Imperilled (S1S2) in Connecticut and Tennessee, Imperilled (S2) in Arkansas (Arkansas Natural Heritage Commission 2013), Indiana and Kansas, Vulnerable (S3 or S3?) in New York, Virginia, and North Carolina and Vulnerable to Apparently Secure (S3S4) in Michigan. Tall Beakrush is Apparently Secure (S4) in Delaware, and is unranked (SNR) in Alabama, Florida, Louisiana, Maryland, Massachusetts, New Jersey, Oklahoma, South Carolina, Texas, and the District of Columbia, and is Unrankable (SU) in Georgia. Tall Beakrush is also unranked (SNR) in Vermont and Mississippi but records for both states appear to be erroneous (see *Global Range*). Tall Beakrush may warrant ranking as a rare species in Florida (Jenkins pers. comm. 2013), given that it is mapped for only one county (Kartesz 2011; Hansen pers. comm. 2013; Wunderlin and Hansen 2013). Additionally, relatively limited occurrence in Alabama, Georgia and Massachusetts (Kartesz 2011) suggests that Tall Beakrush may be marginally rare in those jurisdictions.

Tall Beakrush has the following non-legal state status ranks: Endangered in Kentucky (Kentucky State Nature Preserves Commission 2012), State Threatened in Rhode Island (Enser 2007), "Inventory Element" in Arkansas (Arkansas Natural Heritage Commission 2013), and State Rare in Indiana (Indiana Natural Heritage Data Centre 2013).

Habitat Protection and Ownership

Most or all Tall Beakrush occurrences are within the seasonally flooded zone along the shore that is under Crown ownership (LIANS 2008). Lakeshore plants such as Tall Beakrush receive indirect protection through provincial laws and policies regulating shoreline development and pertaining to the protection of water quality, watercourses, wetlands and riparian buffers. The *Nova Scotia Wetlands Conservation Policy*, *Activities Designation Regulations* and *Environmental Assessment Regulations*, all under the *Environment Act*, the *Forest Act - Wildlife Habitat and Watercourses Protection Regulations*, and the *Off Highway Vehicle Act* all may apply. In practice, however, these regulations are not always known to landowners or may be ignored, especially in relation to activities like removing rocks and removing or mowing vegetation for the creation and maintenance of beaches and boat launches on seasonally exposed Crown-owned shoreline in front of private properties.

At Molega Lake, land ownership adjacent to Tall Beakrush occurrences is with two private landowners. Five of 35 individuals are adjacent to a property with an existing cottage and the remaining 30 are on the adjacent property that is currently undeveloped. All plants are within 16 m of the boundary between these two properties. The boundary is not well marked (Blaney *et al.* pers. obs. 2013).

At Carrigan Lake, the lakeshore adjacent to the areas occupied by Tall Beakrush is either owned outright by Nova Scotia Power (506 of 653 individuals), or is Crown land over which Nova Scotia Power has flowage rights (147 of 653 individuals). Flowage rights are defined under the provincial *Land Registration Act* of 2001, Chapter 6, Section 1, Item 73 (1), which states that a "utility interest" (in this case the right to maintain water levels for power generation such that the land in question is flooded), "shall be enforced with priority over all other interests according to law" (Nova Scotia Office of the Legislative Counsel 2001). Nova Scotia Power is a private corporation that generates 95% of the province's electricity and is regulated under the provincially appointed Nova Scotia Utility and Review Board (Nova Scotia Power 2013). Nova Scotia Power's landholdings on the shore of Carrigan Lake are as narrow as 4 m, and 263 of 653 individuals on the lake are adjacent to very narrow Nova Scotia Power ownership, behind which land is privately owned and potentially subject to development. An additional three individuals on the south shore of the lake are near to the boundary of the provincial Lake Rossignol Wilderness area, which is separated from the lakeshore by a 4 m wide zone of Nova Scotia Power ownership and a 26 m wide zone of undesignated Crown land over which Nova Scotia Power has flowage rights.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Sean Blaney is the Botanist and Assistant Director of the Atlantic Canada Conservation Data Centre (AC CDC), where he maintains status ranks and a rare plant occurrence database for each of the three Maritime provinces. Since beginning with the AC CDC in 1999, he has documented dozens of new provincial records for vascular plants and thousands of rare plant localities during extensive fieldwork across the Maritimes. Sean is a member of the COSEWIC Vascular Plant Species Specialist Subcommittee, the Nova Scotia Atlantic Coastal Plain Flora Recovery Team, and has authored or co-authored numerous COSEWIC and provincial status reports. Prior to employment with AC CDC, Sean received a B.Sc. in Biology (Botany Minor) from the University of Guelph and an M.Sc. in Plant Ecology from the University of Toronto, and worked on biological inventory projects in Ontario as well as spending eight summers as a naturalist in Algonquin Park, where he co-authored the second edition of the park's plant checklist.

COLLECTIONS EXAMINED

No specimens were examined during preparation of the report. The only Canadian specimens were collected upon the initial discovery of the Carrigan Lake subpopulation in 2008 by AC CDC, and the Keddy Cove, Molega Lake subpopulation by Nick Hill in 2009.

Appendix 1. Named lLakes within 10 km of known Tall Beakrush occurrences, with extent and date(s) of shoreline plant surveys since 2007.

Lake Name	Extent of Shoreline Coverage	Within 10 km of:
Black Rattle	Comprehensive (2007, 2008, 2013)	Molega
Beartrap [& Cameron]	Comprehensive (2007, 2012)	Carrigan
Cameron [& Beartrap]	Comprehensive (2007, 2012)	Carrigan
Second Christopher	Comprehensive (2007, 2012)	Carrigan
Beavertail	Comprehensive (2008)	Molega
Elizabeth	Comprehensive (2008)	Molega
Laurel [& Third Christopher]	Comprehensive (2008)	Carrigan
Long	Comprehensive (2008)	Molega
Russell	Comprehensive (2008)	Carrigan
Third Christopher [& Laurel]	Comprehensive (2008)	Carrigan
Whynott	Comprehensive (2008)	Molega
Bull Moose	Comprehensive (2009)	Carrigan
Little Rocky	Comprehensive (2009)	Carrigan
Carrigan	Comprehensive (2009, 2013)	Carrigan
Annis	Comprehensive (2010)	Molega
Apple Tree	Comprehensive (2010)	Carrigan
Big Rocky	Comprehensive (2010)	Carrigan
First Christopher	Comprehensive (2010)	Carrigan
Fourth Christopher	Comprehensive (2010)	Carrigan
Little Ponhook	Comprehensive (2010)	Molega
Moccassin	Comprehensive (2010)	Carrigan
Telfer	Comprehensive (2010)	Carrigan
Hog	Comprehensive (2011)	Molega
Moosehorn	Comprehensive (2012)	Carrigan
Bradley	Comprehensive (2013)	Carrigan
Cannon	Comprehensive (2013)	Carrigan
Loon	Comprehensive (2013)	Carrigan
McBride	Comprehensive (2013)	Carrigan

Lake Name	Extent of Shoreline Coverage	Within 10 km of:
Murphy	Comprehensive (2013)	Carrigan
Payzant	Comprehensive (2013)	Carrigan
Beaverdam	Near comprehensive (2007)	Molega
Seven Mile	Near comprehensive (2008)	Molega
Fox	Near comprehensive (2011)	Molega
Ponhook	~75% coverage (2007-2012)	Molega
Shingle	~75% coverage (2008-2012)	Molega
Molega	85% coverage (2007-2013)	Molega
Turtle	Casual shore coverage (~2009)	Carrigan
McLean	Casual shore coverage (2012)	Carrigan
Cow Moose [West]	spot visit (2009)	Carrigan
Gludogan	spot visit (2009)	Carrigan
McGuire	spot visit (2013)	Carrigan
Barney	never visited	Carrigan
Black	never visited	Carrigan
Cow Moose [East]	never visited	Molega
Faulkner	never visited	Molega
Fire	never visited	Molega
Fisher	never visited	Molega
Harley	never visited	Molega
Horseshoe	never visited	Molega
Huey	never visited	Molega
Irwin	never visited	Carrigan
Little Moose	never visited	Molega
Menchan	never visited	Carrigan
Oickle	never visited	Molega
Pollock	never visited	Carrigan
Prescott	never visited	Molega
Rhyno	never visited	Molega
Slauenwhite	never visited	Molega

Lake Name	Extent of Shoreline Coverage	Within 10 km of:
Weagle	never visited	Molega
Woolenhaupt	never visited	Molega

Appendix 2. Species associated with Tall Beakrush in order of frequency, based on AC CDC (2013) records of associated species at 30 occurrences of Tall Beakrush at Carrigan and Molega Lakes. * = Atlantic Coastal Plain species.

Common Name	Species	# Sites (n=30)
Virginia Marsh St. John's Wort	*Triadenum virginicum**	19
Eaton's Witchgrass	*Dichanthelium spretum**	17
Three-Way Sedge	*Dulichium arundinaceum*	15
Bog Aster	*Oclemena nemoralis*	13
Sweet Gale	*Myrica gale*	10
Twig Rush	*Cladium mariscoides*	10
Pickerel Weed	*Pontederia cordata*	10
Large Cranberry	*Vaccinium macrocarpon*	9
Royal Fern	*Osmunda regalis var. spectabilis*	8
Swamp Loosestrife	*Lysimachia terrestris*	8
Blue-Joint Reedgrass	*Calamagrostis canadensis*	6
Carolina Grass-Leaved Goldenrod	*Euthamia caroliniana**	5
Canada Rush	*Juncus canadensis*	5
Lance-Leaf Violet	*Viola lanceolata*	5
Leatherleaf	*Chamaedaphne calyculata*	4
Spoon-Leaved Sundew	*Drosera intermedia*	4
Glossy Buckthorn	*Frangula alnus*	3
Brown Beakrush	*Rhynchospora fusca*	3
New Belgium American-Aster	*Symphyotrichum novi-belgii*	3
Broadleaf Arrowhead	*Sagittaria latifolia*	2
Brook-Side Alder	*Alnus serrulata**	2
Roundleaf Sundew	*Drosera rotundifolia*	2
Brown-Fruited Rush	*Juncus pelocarpus*	2
American Water-Lily	*Nymphaea odorata*	2
Rough Bentgrass	*Agrostis scabra*	2
Northern Bugleweed	*Lycopus uniflorus*	2

Common Name	Species	# Sites (n=30)
Little Prickly Sedge	*Carex echinata*	2
Long Sedge	*Carex folliculata*	1
Creeping Spike-Rush	*Eleocharis palustris*	1
Marsh Fern	*Thelypteris palustris var. pubescens*	1
Northern Meadow-Sweet	*Spiraea alba var. latifolia*	1
Robbins Spikerush	*Eleocharis robbinsii*	1
Perennial Bentgrass	*Agrostis perennans*	1
Hemlock Water-Parsnip	*Sium suave*	1
Virginia Chainfern	*Woodwardia virginica**	1
Seven-Angled Pipewort	*Eriocaulon aquaticum*	1
Carolina Yellow-Eyed-Grass	*Xyris difformis**	1
Broad-Leaf Cattail	*Typha latifolia*	1
Common Buttonbush	*Cephalanthus occidentalis*	1